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The Corrosion Behaviour of Zinc Metal in Acidic Solution of Triphenyl Tetrazolium Chloride

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In the present work, the authors have investigated the effect of triphenyl tetrazolium chloride as inhibitor for acid corrosion of zinc.

INTRODUCTION

Many data on using sulphur-containing organic compounds such as thiourea and its derivatives as inhibitors have been published[1]. However, such compounds undergo chemical changes to produce S^{2-} and HS^{-1} ions, *i.e.* they may become corrosion promoters[2]. Therefore, it is worthwhile to search for efficient sulphur free inhibitors as triazoles[3], benzotriazoles[4] and polyvinyl pyrrolidones[5].

The purpose of the present work is to investigate the effect of triphenyl tetrazolium chloride (TTC) as inhibitor for acid corrosion of Zn. This compound has many biological applications[6]. The effects of TTC on the corrosion rate, corrosion potential and the apparent activation energy of corrosion of Zn metal in 1.0 M H_2SO_4 were investigated. The results were analyzed with a view to determine the inhibiting efficiency of this compound at various temperatures and concentrations and to elucidate the mechanism of inhibition.

EXPERIMENTAL

Triphenyl tetrazolium chloride (TTC) was of the highest purity available. The zinc used was spectroscopically pure (purity, 99.9%). The weight loss was measured on sheets of apparent surface area 16.56 cm^2. The test samples were degreased and abraded with successively finer grades of emery paper down to 00 grade. The corrosion rate was calculated on the basis of the apparent surface area. The concentration of TTC solutions studied in 1.0 M H_2SO_4 varied between 10^{-4} M and 0.01 M. The immersion time at different temperatures was 30 min. The results of the weight loss experiments are the mean of eight runs, each with a fresh electrode surface and fresh batch of electrolyte. The percentage inhibition P was calculated from the relation:

$$P = 100(1 - W_2/W_1) \qquad (1)$$

where W_1 and W_2 are the corrosion rates in the absence and in the presence of TTC inhibitor respectively.

The potential-time measurements were carried out using Zn electrodes as was previously reported[7].

RESULTS AND DISCUSSION

Fig. 1 shows the variation in the protection efficiency of Zn metal as a function of the concentration of triphenyl tetrazolium chloride (TTC) in 1.0 M sulphuric acid solution at different temperatures. As shown, the percentage inhibition increases with increasing TTC concentration in the medium, approaching complete protection (73%) in 0.01 M TTC concentration at 30°C. In addition, the protection efficiency increases with decreasing temperature. However, these results are different from that observed in the case of Al in HCl using TTC as an inhibitor[8]. There, it was found that the temperature has two opposing effects on the efficiency of TTC, *i.e.*, there is an inflection temperature (55°C) below which the efficiency increases and above which it decreases with rise of temperature. The above results suggested that the inhibition may be due to the formation of an insoluble Zn-TTC film on the metal surface. Fig. 2 shows the corrosion rate of Zn in 1.0 M H_2SO_4 as a function of the concentration of TTC at various temperatures. Clearly, the corrosion rate decreases as the concentration of the TTC increases. Graphical representation of the inhibition function according to a Langmuir isotherm

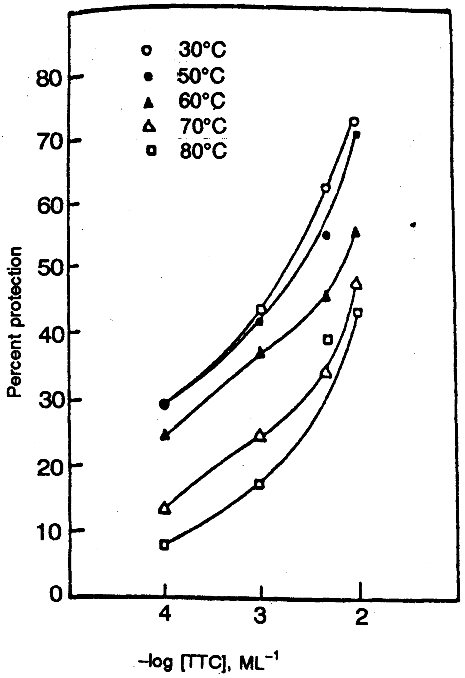

Fig. 1 Effect of concentration of triphenyl tetrazolium chloride on the protection efficiency of zinc in 1.0 M H_2SO_4 at various temperatures.

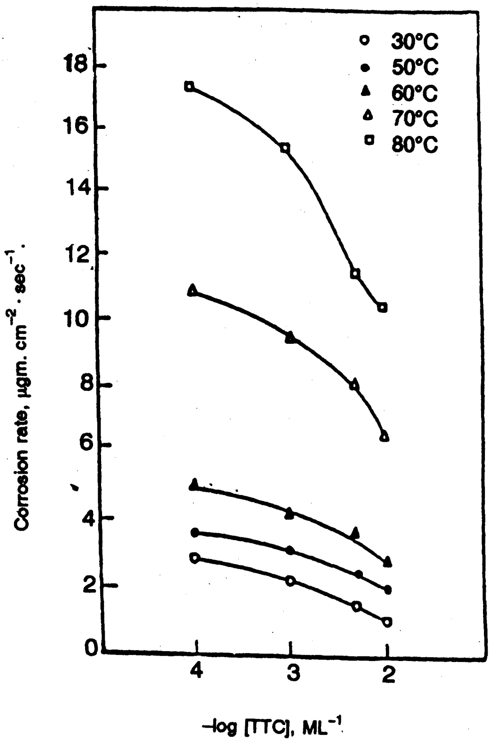

Fig. 2 Effect of concentration of triphenyl tetrazolium chloride on the corrosion rate of zinc in 1.0 M H_2SO_4 at various temperature.

relationship (*cf.* equation-2) does not show an obvious linear relationship. This indicates that the inhibition function is not in accord with adsorption equation-2:

$$\log (p/1 - p) = \log (I) + \text{constant} \qquad (2)$$

where (I) is the inhibitor concentration.

These results suggested that the protection imparted by TTC agrees with the film formation[9,10], where inhibition is due to the formation of a protective film on the metal surface. The diffusion of metal ions through this film becomes the rate-determining step. These results are in agreement with the previous results reported for the inhibition of Zn corrosion by polyvinyl-pyrrolidones and polyvinylpyridine[7].

Fig.-4 shows an Arrhenius plot of the corrosion process of Zn in 1.0 M H_2SO_4 (using Arrhenius equation-3):

$$\log \text{corrosion rate} = -E_a/RT + B \qquad (3)$$

Here, E_a is the apparent activation energy, R is the universal gas constant and B is a constant.

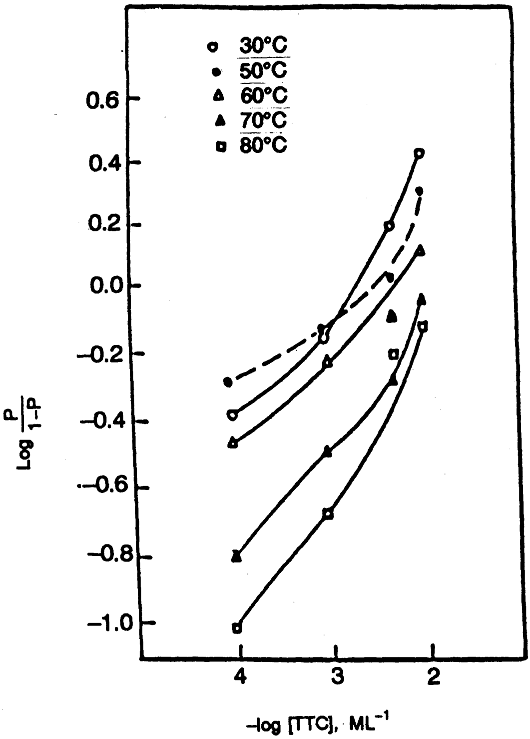

Fig 3 Plot of log P/(1 − P) versus log concentration of triphenyl tetrazolium chloride for zinc in 1.0 M H_2SO_4 at various temperatures.

The results fit a satisfactory straight line with an activation energy of 11.9 Kcal/mole. This value is comparable with some values reported by Desai *et.al*[11]. It is also of the order of the activation energies encountered for the hydrogen evolution reaction[12]. The calculated values of the apparent activation energies in the presence of 10^{-3} and 10^{-2} M inhibitor concentration are 11.5 Kcal/mole and 9.21 Kcal/mole, respectively (*cf.* Fig. 5). These differences are not considered to be significant. Thus, the presence of TTC does not seriously affect the activation energy of the corrosion process. The above evidence indicates that the presence of TTC does not change the mechanism or the neture of the rate-determining step of the corrosion process, although it significantly reduces its rate.

The open-circuit potential of a zinc elecrode immersed in 1.0 M sulphuric acid in the absence and in the presence of TTC solutions of concentration ranging between 5×10^{-2} M and 10^{-3} M was followed as a function of time till steady state values are established. The results of these measurements are shown in Fig.-6.

It is obvious that the potential shifts with time in the negative direction till the steady state is attained after about 80 min. It is noticed that the steady state potential values E_{corr} are shifted towards the noble direction under the influence of the inhibitor. The shift of potential towards a less negative value increases

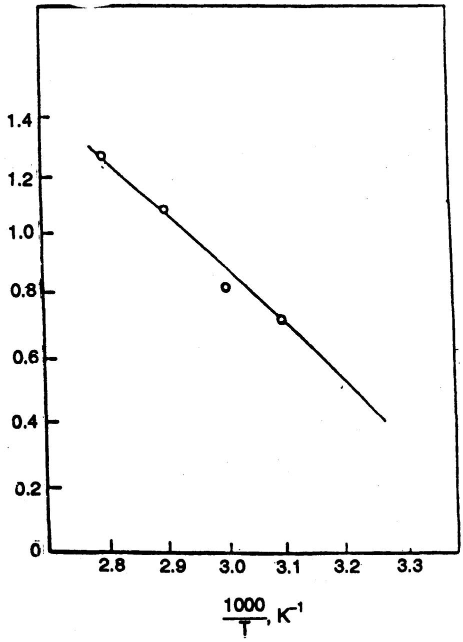

Fig. 4 Arrhenius plot of the corrosion rate of zinc in 1.0 M H_2SO_4 in the absence of TTC

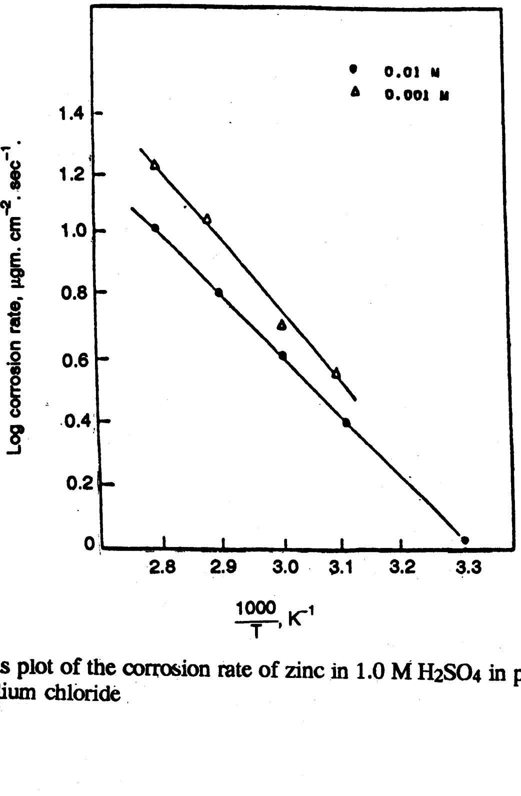

Fig. 5 Arrenius plot of the corrosion rate of zinc in 1.0 M H_2SO_4 in presence of triphenyl tetrazolium chloride

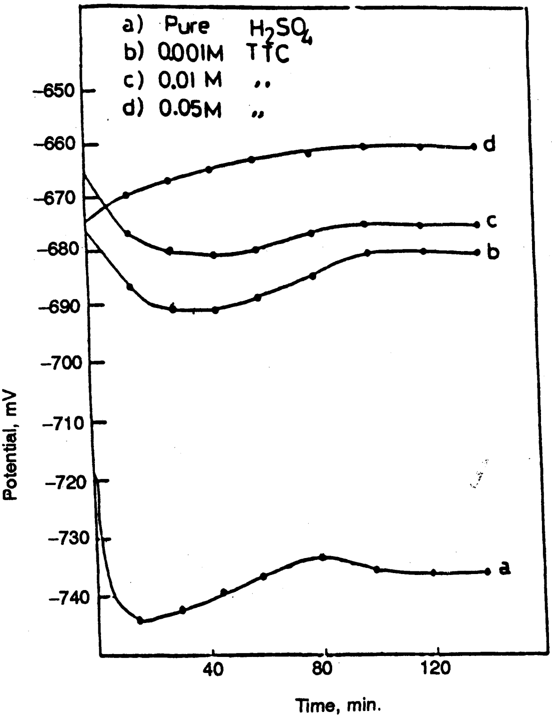

Fig. 6 Potential-time curve for the zinc electrode in 1.0 M sulphuric acid solution in the presence of various concentration of triphenyl tetrazolium chloride.

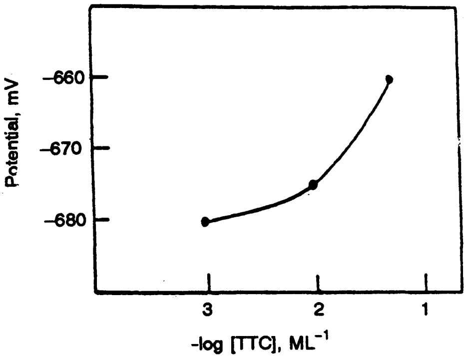

Fig. 7 Plot of zinc potential versus log concentration of triphenyl tetrazolium chloride in 1.0 M sulphuric acid solution.

with increasing TTC concentration as shown in Fig. 7. It can be concluded that, TTC is a good inhibitor for the acid corrosion of zinc metal in acidic solution.

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